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MONITORING REPORT
1984 - 1986
UPPER OTTAWA STREET LANDFILL
REGION OF HAMILTON-WENTWORTH

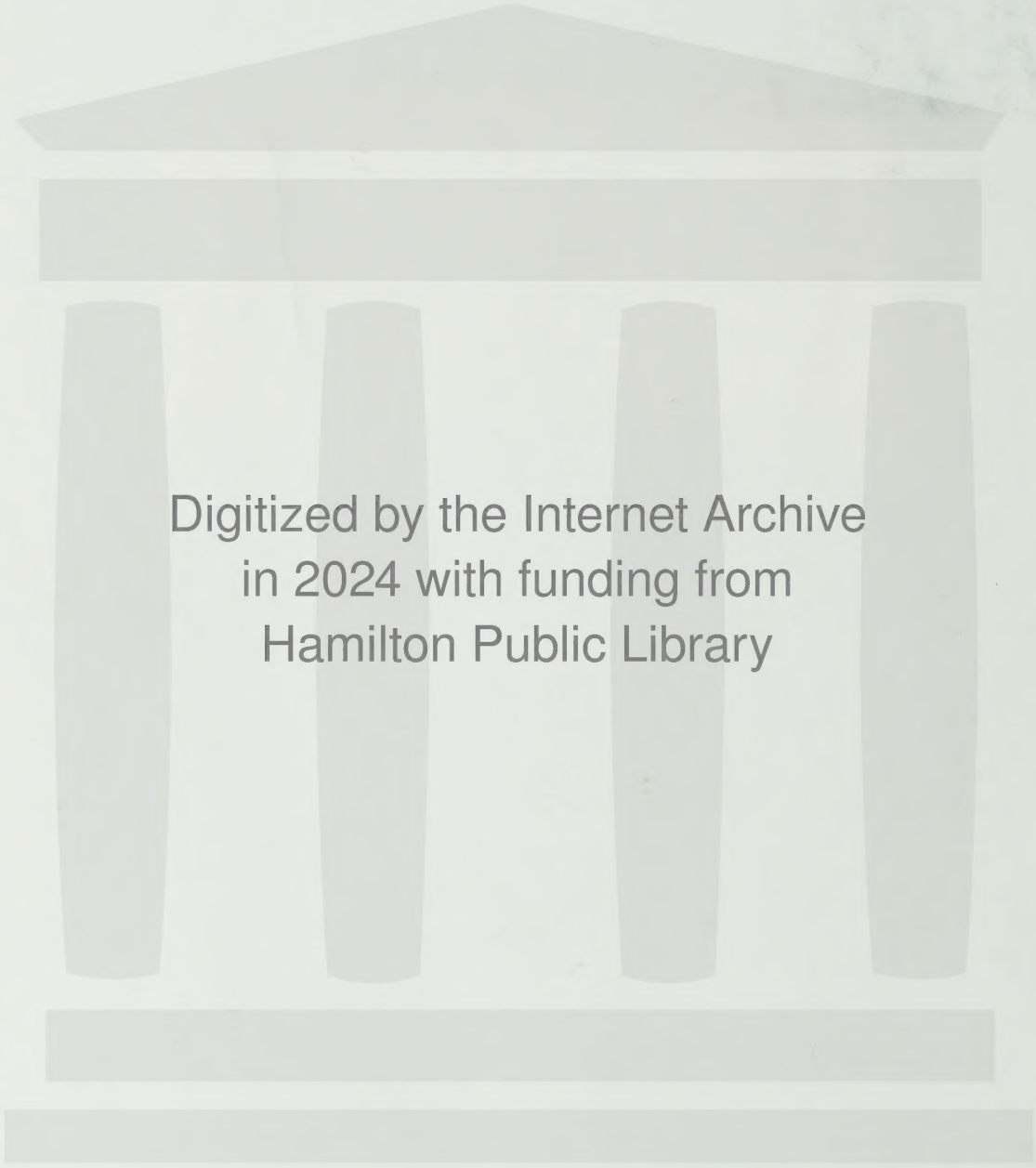
morrison beatty limited
consulting engineers and hydrogeologists

MONITORING REPORT
1984 - 1986
UPPER OTTAWA STREET LANDFILL
REGION OF HAMILTON-WENTWORTH

M O R R I S O N B E A T T Y L I M I T E D
4500 Dixie Road
Mississauga, Ontario
(416) 624-9308

DECEMBER, 1986
PROJECT NO. 461-851

B.W. BEATTY, P.Eng.



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consulting engineers and hydrogeologists
4500 dixie road, unit 12a, mississauga, ontario L4W 1V7 (416-624-9308)

December 12, 1986

Mr. R.F. Palombella
Operations Manager
The Regional Municipality of Hamilton-Wentworth
Department of Engineering
71 Main Street West
Hamilton, Ontario
L8N 3T4

re: 1984-1986 Monitoring Report
Upper Ottawa Street Landfill
Our File No. 461-851

Dear Sir:

We are pleased to submit our report on the 1984-1986 monitoring program at the Upper Ottawa Street landfill. The report evaluates the monitoring data collected by the Region and Morrison Beatty Limited from November 1984 to June 1986.

In preparation of this report we thoroughly reviewed the comprehensive study of the site by the University of Waterloo Research Institute. The WRI report, in combination with our review of historical monitoring at the site allowed us to clarify previous uncertainties about the landfill impacts.

We conclude that the overall site impacts are minor. We have developed a scaled-down monitoring program that better identifies the observed impacts. We welcome an opportuity to present the results of our evaluation to the MoE.

Yours very truly,
MORRISON BEATTY LIMITED

Brian W. Beatty, P.Eng.

BWB/lf

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1.0 INTRODUCTION

1.1 Background

This monitoring program includes all field data collected at the Upper Ottawa Street landfill from November 1984 to June 1986. Monitoring of the landfill is routinely carried out by the Region of Hamilton-Wentworth. The data is provided to consultants to prepare an annual monitoring report. Some field work is also contracted to the consultants. Morrison Beatty Limited was retained by the Region's Department of Engineering to prepare the current monitoring report.

The Terms of Reference for this study was divided into two tasks. Task A involved the sampling and measurement of streamflow at five stations on Redhill Creek by Morrison Beatty Limited. The samples were analyzed by the Regional Laboratory. Task B involved an assessment of groundwater and surface water samples. In addition, Task B was to include a landfill inspection and a mass-balance calculation from data obtained under Task A. A copy of the Terms of Reference for this study is included in Appendix G. On November 27, 1986 we were authorized to incorporate the 1986 monitoring data into this report as well.

We received the following 1984, 1985 and 1986 monitoring results:

Groundwater:	wells	-	BH 1, BH 9, BH 11, BH 12 (all bedrock)
	dates	-	Nov. 6/84, June 6/85, Sept. 12/85, June 6/86
Surface Water:	stations	-	SW 1, SW 2, SW 4, SW 7, SW Tributary
	dates	-	Nov. 6/84, June 6/85, Sept. 11/85, June 6/86
Sediment:	stations	-	SW 1, SW 2, SW 4, SW Tributary
	dates	-	Nov. 6/84, June 6/85, June 6/86
Leachate:	location	-	MH 1 (Manhole), June 6/86
Methane:	monitors	-	GM 1, 2, 3, 4, 5, 6, 7, 9, Quonset Hut
	dates	-	Aug. 17/84, Oct. 18/84, Apr. 23/85, July 9/85

All samples except surface water on September 12, 1985 were collected by Regional staff. Sampling protocol is available from the Department of Engineering. The samples were analyzed in the Region's laboratory. The analytical procedures can be obtained directly from the laboratory. The monitoring locations are identified on Figure 1 and on Map 1 in the map pocket.

Analysis of the above data in the absence of background information on monitor construction and location and the site geology proved to be ineffective. We requested the Region to provide us with a copy of the preceeding monitorng report by Gartner Lee Associates Limited (GLAL) (dated January, 1985). The GLAL report included logs for the observation wells and gas probes and graphs of previous water quality analyses.

After completion of our data evaluation in mid-April, we were informed by the MoE that the comprehensive hydrogeologic investigation of the landfill by the University of Waterloo Research Institute (WRI) was being released. The final draft of this document was provided by the MoE. The WR 1 studies focused exclusively on the impact of the landfill on groundwater.

The WRI report is described as "the most comprehensive investigation undertaken to date at any Canadian landfill site on fractured rock". Considering the large volume of scientific data in the WR 1 report, we have relied on the research material to support our conclusions and recommendations.

- Stream gauging and surface water sampling locations
- Groundwater sampling locations

Limit of Landfill materials (after Cherry et al., 1984)

UPPER OTTAWA STREET LANDFILL

ANNUAL MONITORING REPORT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

MONITORING LOCATIONS

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2.0 MONITORING RESULTS

2.1 Leachate

2.1.1 Leachate Quality

Leachate quality is monitored in the perimeter leachate collection system at Manhole No. 1 (MH 1). The results are listed in Appendix A. The 1984-86 results show significant fluctuation in quality. For example chloride and sulphate decreased from 1000's of mg/L in November 1984 to 10's of mg/L in September 1985 and then increased back to 1000's of mg/L in June 1986.

In general, the leachate chemistry is typical of landfills undergoing active decomposition. There has been no real change in the strength of the leachate since the first samples were checked by the MoE in 1978 ("Effects of the Upper Ottawa Street Landfill on Redhill Creek"). The current strength and fluctuation pattern can be expected for another decade or so. Then, a gradual decay in leachate strength will occur over the next 10 or 15 decades.

2.1.2 Leachate Movement

Previous studies show that the water table is mounded in the landfill. Our field reconnaissance of the landfill confirmed the mounded condition as manifest by leachate springs around the toe of the site. The springs are identified on Map 1 (map pocket). They occur mainly on the southeast and north perimeter, 3 to 5 m above the toe of the landfill.

The total seepage flow on September 12, 1985 was estimated to be less than 1.0 L/s. Evidence of dry seepage areas indicates that higher flows occurred earlier in the year. Many of the minor seepages evaporate within a few metres of the point of discharge. A few seepages trickled into Redhill Creek, although no visual impacts were noted.

2.2 Surface Water

2.2.1 Surface Flows

Streamflow measurements were made on September 12, 1985 at stations SW 1, SW 2, SW 3 and SG 4 using an OTT meter. Velocity measurements were made at 8 to 10 locations across the streambed. The stream profiles and measurement locations are shown in the stream gauging records in Appendix B. Flow over the weir at SW 7 was determined by using a bucket of known volume.

The streamflow ranged from about 13 L/s upstream of the landfill to 27 L/s at Albion Falls (SW 7). Flow in the tributary below the landfill was about 11 L/s. A 2 L/s increase in streamflow was noted between stations SW 4 and SW 2, upstream and downstream of the landfill. Assuming a 1.0 L/s contribution from leachate seepage, the balance of the increased flow would be groundwater discharge from the bedrock.

The WR 1 research showed the hydraulic conductivity (K) of the dolostone bedrock to be in the order of 4×10^{-3} cm/s. With a K of 4×10^{-3} cm/s and a horizontal gradient in the order of 0.01, groundwater discharges of about 0.5 L/s, from each side of the stream (i.e., total of 1.0 L/s) are possible. Therefore the 2 L/s increase in flow along the 800 m length of the landfill appears to be valid.

2.2.2 Surface Water Quality

The surface water quality for the period 1981 to 1985 is listed in Appendix C. Selected results are summarized on Figures 2 to 7. An interpretation of the key results is given below:

Conductivity

- November 1984 levels at SW 1, SW 2 and SW 4 are all greater than 11,000 umhos/cm which is a factor of 10 higher than normal; the reason for this anomally cannot be determined without a full analysis of the major ions; it appears to be a lab error since chloride and alkalinity were not unusually elevated in the November 1984 analyses; a 10% increase occurred between SW 4 and SW 2 on the June and September 1985 dates; background quality was monitored at SW 1, 400 m downstream of landfill; June 1986 levels were significantly lower (470 umhos/cm) at SW 2 compared to previous levels of over 1000 umhos/cm; the reason for this is not apparent.

Chloride

- upstream (SW 4) loading in the November 1984 to June 1986 samples ranged from 145 to 200 mg/L which is generally higher than in previous monitoring; an increase in chloride of 6 to 20% occurs between SW 4 and SW 2 (upstream and downstream of the landfill) in the last four samples; highest level at SW 2 is less than the maximum desirable concentration (MDC) for drinking water of 250 mg/L; background quality was monitored at SW 1.

Ammonia

- upstream (SW 4) loading in the November 1984 to June 1986 samples ranged from 0.2 to 0.9 mg/L which is generally higher than in previous monitoring; a maximum of 3.2 mg/L at SW 2 and 2.0 mg/L at SW 1 was recorded in November 1984; levels of un-ionized ammonia between SW 4 and SW 1 probably exceed the MoE water quality objective of 0.02 mg/L during the summer and early fall months (both pH and temperature are needed to determine un-ionized ammonia levels); ammonia levels at SW 1 and SW 2 were 2 to 3 times upstream levels in September 1985 and June 1986.

Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
3. Dec. 8 1982
4. Jun. 7 1983
5. Nov. 11 1983
6. May 10 1984
7. Nov. 6 1984
8. Jun. 6 1985
9. Sep. 11 1985
10. Jun. 23 1986

UPPER OTTAWA STREET LANDFILL

ANNUAL MONITORING REPORT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

CHLORIDE mg/L

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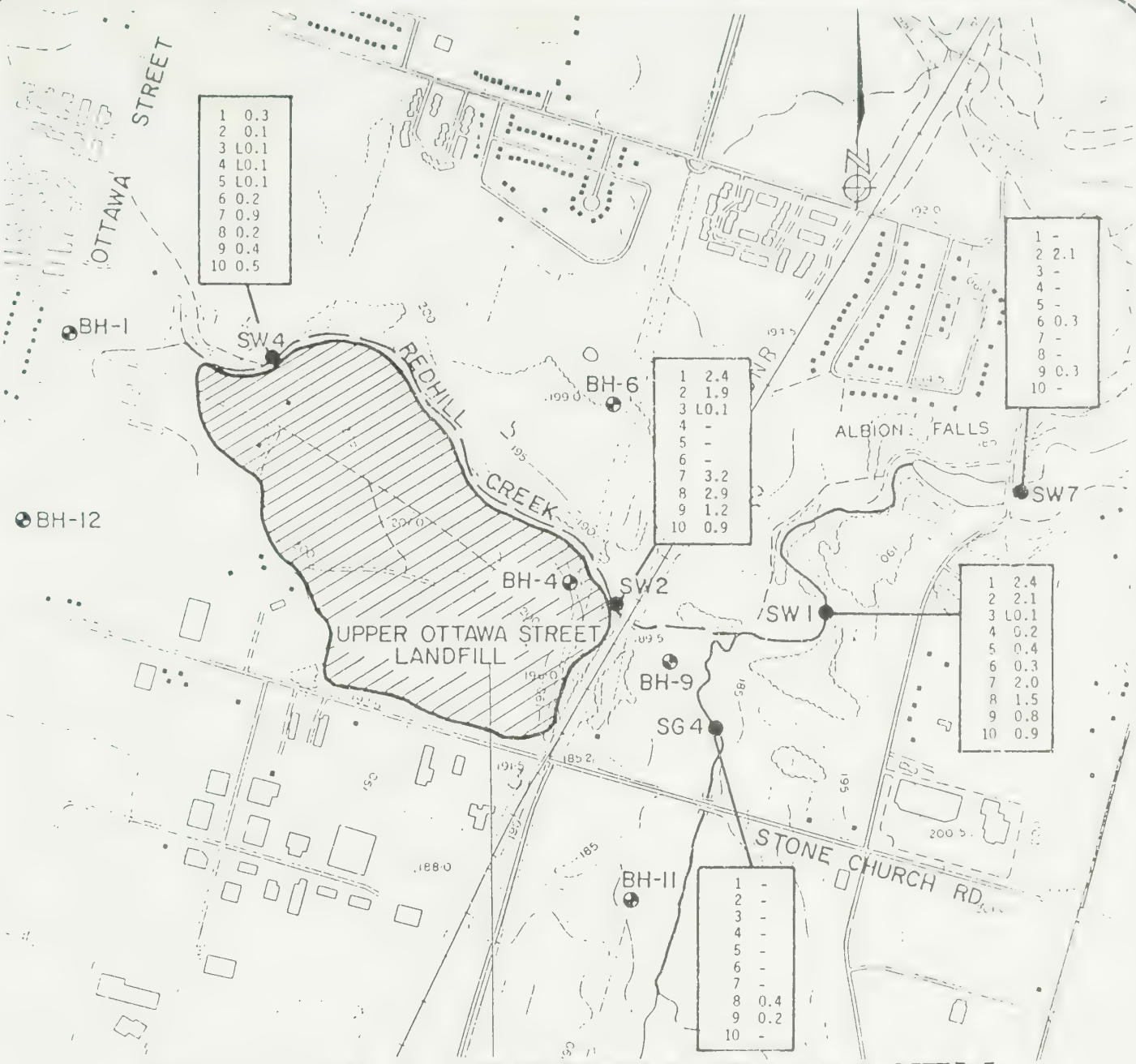

RED HILL CREEK QUALITY

Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
3. Dec. 8 1982
4. Jun. 7 1983
5. Nov. 11 1983
6. May 10 1984
7. Nov. 6 1984
8. Jun. 6 1985
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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

AMMONIA mg/L

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RED HILL CREEK QUALITY

1/2 0 1/2 mile

SCALE 1:10,000

500 0 500 metres

Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
3. Dec. 8 1982
4. Jun. 7 1983
5. Nov. 11 1983
6. May 10 1984
7. Nov. 6 1984
8. Jun. 6 1985
9. Sep. 11 1985
10. Jun. 23 1986

UPPER OTTAWA STREET LANDFILL

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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

BOD mg/L

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RED HILL CREEK QUALITY

Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
3. Dec. 8 1982
4. Jun. 7 1983
5. Nov. 11 1983
6. May 10 1984
7. Nov. 6 1984
8. Jun. 6 1985
9. Sep. 11 1985
10. Jun. 23 1986

UPPER OTTAWA STREET LANDFILL

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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

IRON mg/L

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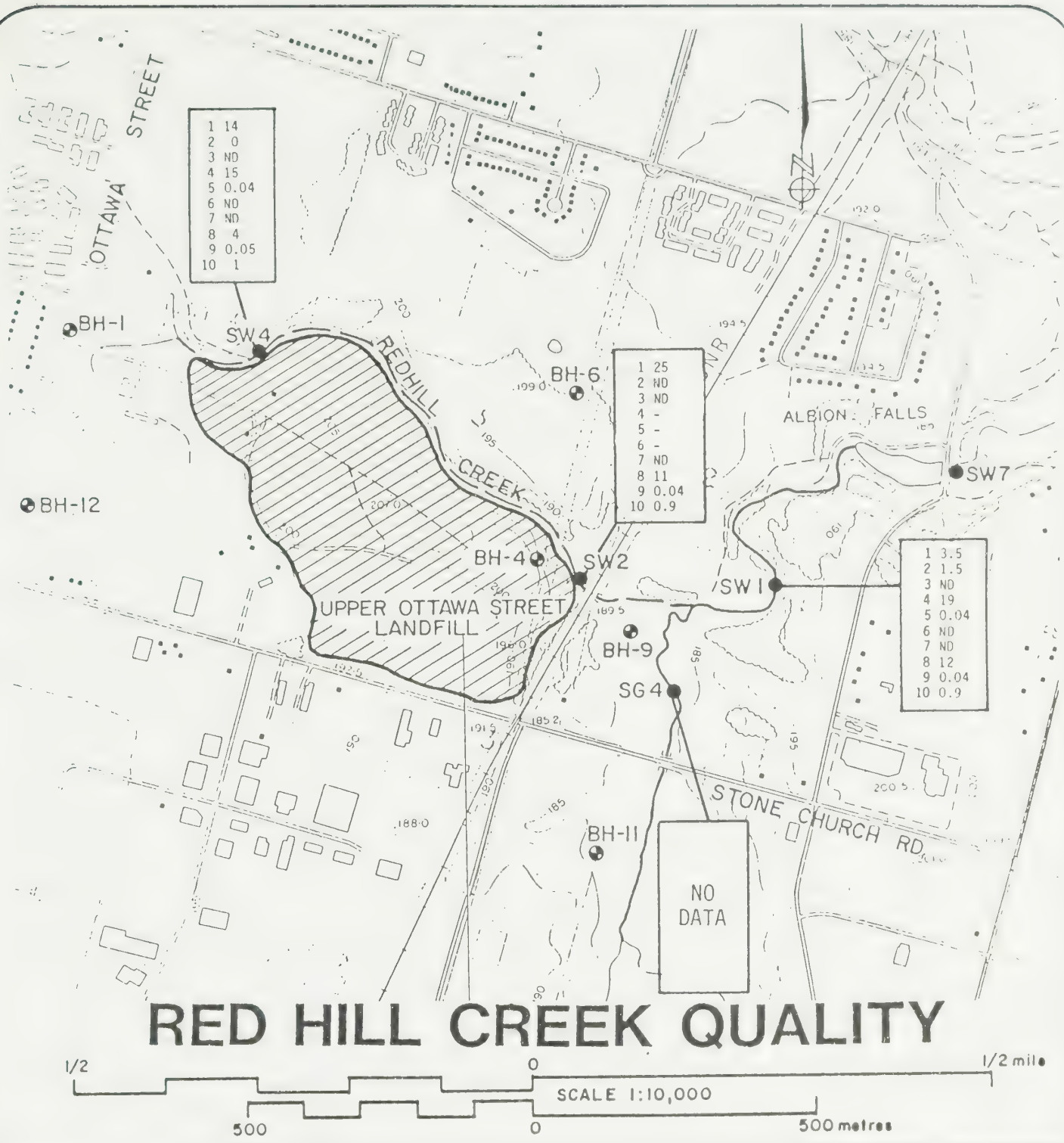

RED HILL CREEK QUALITY

Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
3. Dec. 8 1982
4. Jun. 7 1983
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7. Nov. 6 1984
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UPPER OTTAWA STREET LANDFILL

ANNUAL MONITORING REPORT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

PHENOL ug/L

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Test Dates

1. Nov. 26 1981
2. Jun. 3 1982
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UPPER OTTAWA STREET LANDFILL

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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

PCB 0.06 - Creek Sample, µg/l
[0.04] - Sediment Sample, µg/g

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Iron

- iron was found above the water quality objective of 0.3 mg/L at all stations in November, 1985 (0.7 to 2.1 mg/L); the June, 1985 samples for SW 2 and SW 4 were below the limit; the September, 1985 sample at SW 2 marginally exceeded the limit (0.4 mg/L).

BOD

- BOD was low (5 mg/L) above and below the landfill in November, 1984; in June 1985 samples, the BOD increased from 90 mg/L at SW 4 to 255 mg/L at SW 2; in September, 1985, the BOD at SW 7 (Albion Falls) was 362 mg/L compared to 4.5 mg/L at SW 2 (below landfill); all June 1986 samples had zero BOD.

Phenol

- impact due to leachate only noted in June 1985 sample, when phenol increased from 4.08 ug/L at SW 4 to 11.22 ug/L at SW 2; the MoE objective for phenol in surface water is 1 ug/L.

PCB

- PCB's were analyzed for surface water samples in June and September 1985 and June 1986; they are considered by the MoE to have "zero tolerance limits" since they may accumulate in stream sediments; PCB's increased from 0.04 ug/L at SW 4 to 0.06 ug/L at SW 2 in June 1985; a level of 0.07 ug/L was noted in the downstream tributary in June 1985, indicating PCB sources other than the landfill are present in the area; PCB's were not detected at any stations except SW 7 (Albion Falls) in September, 1985; in June, 1986, PCB increased from 0.6 ug/L above the landfill to 6.0 ug/L below the landfill and further to 136 ug/L at SW 1 downstream of the site.

- PCB's in the stream sediments are summarized in Appendix D; the June, 1985 and June, 1986 sediment samples both have less PCB's below the landfill (SW 2) than above the landfill (SW 4); further downstream at SW 1, PCB's in the sediment increases just above the upstream levels; PCB's in the tributary stream sediments are similar to the levels found upstream of the landfill.

2.3 Groundwater

2.3.1 Monitoring Details

Groundwater was monitored in four bedrock observation wells. The well logs and construction details are included in previous reports by Gartner Lee Associates Limited (GLAL). For reference purposes, the monitoring well logs, water levels, and screen intervals have been summarized from the original 1980 GLAL report and the GLAL monitoring report for 1982-84. This data is listed in Table 1.

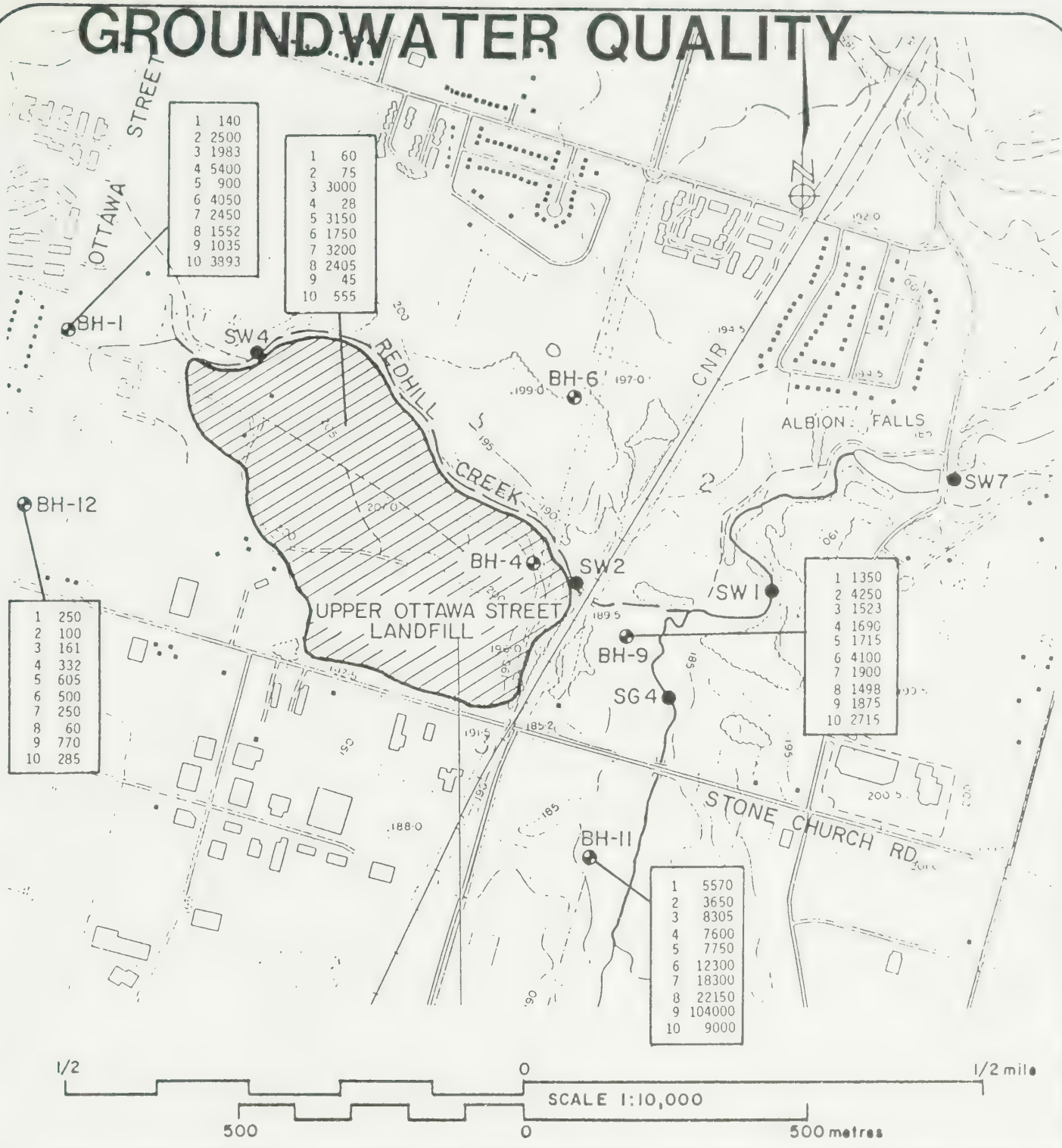
It is noted that the deepest well in each well nest is monitored. One well (BH 11) is screened in Rochester shale and the other three are screened in dolostone. Rochester shale was encountered just above the screened interval in BH 1. Groundwater in the dolostone and shale exhibit much different quality.

Two of the wells (BH 1 and BH 12) are upgradient of the landfill and represent background conditions. The other two, BH 9 and BH 11, are located 100 and 300 m downgradient of the landfill.

2.3.2 Groundwater Quality

The groundwater chemistry for the 1981 to 1986 monitoring period is listed in Appendix E. The chloride, alkalinity, sulphate and ammonia results are summarized on Figures 8 to 11. A general evaluation of the recent trends in groundwater quality is summarized below.

GROUNDWATER QUALITY



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UPPER OTTAWA STREET LANDFILL

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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

CHLORIDE mg/L

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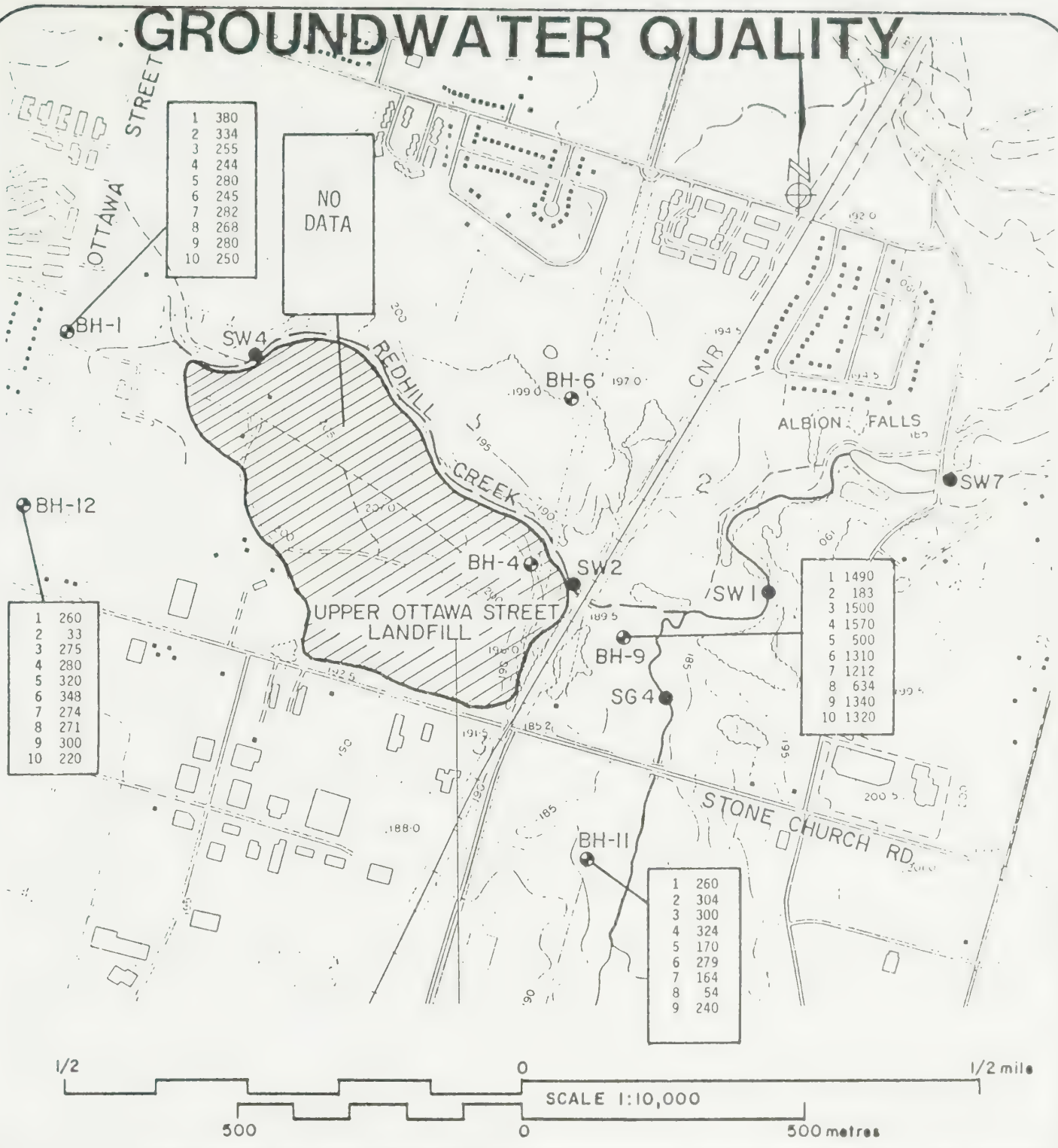
GROUNDWATER QUALITY



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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

ALKALINITY mg/L

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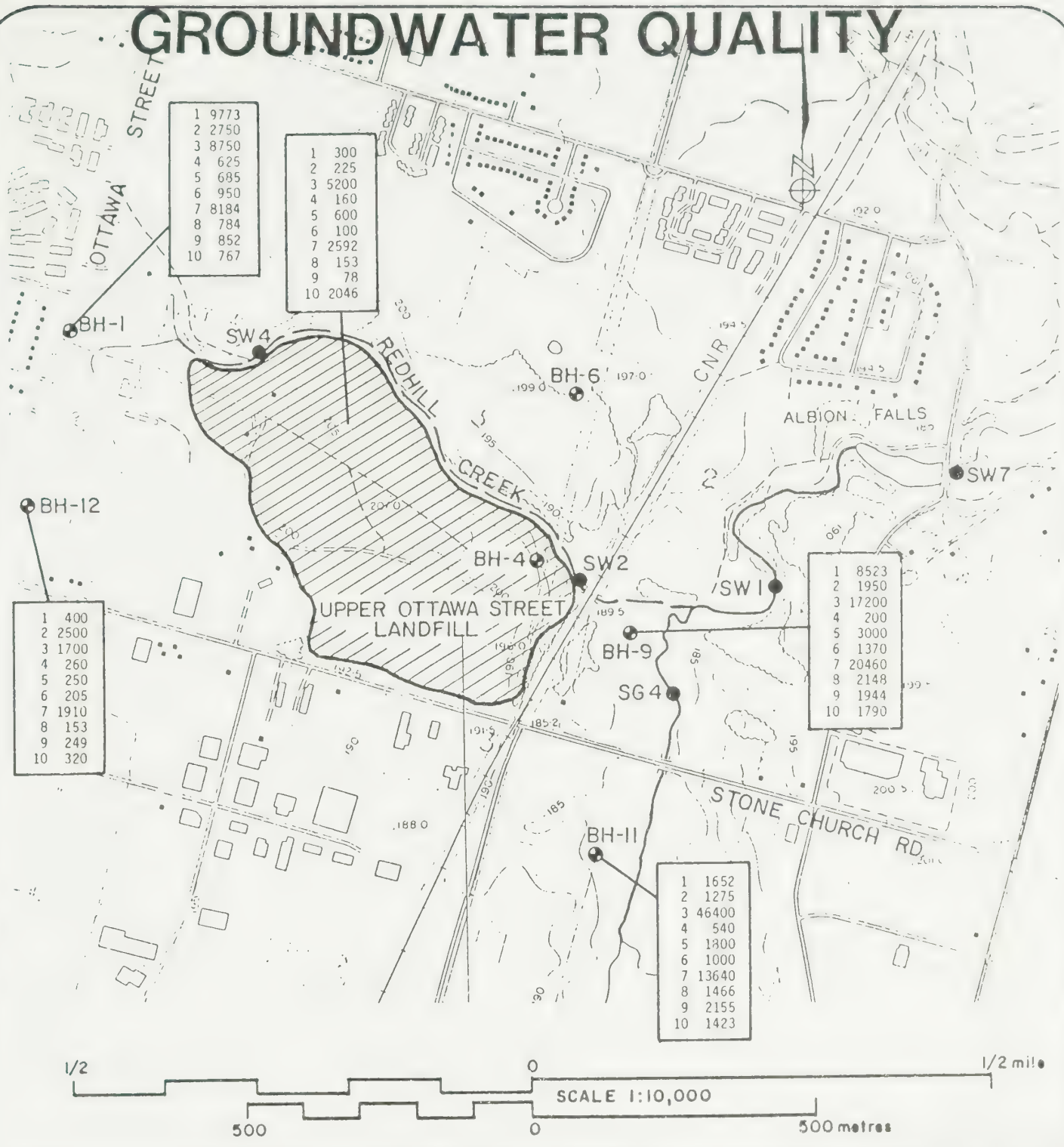
GROUNDWATER QUALITY



Test Dates

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SULPHATE mg/L

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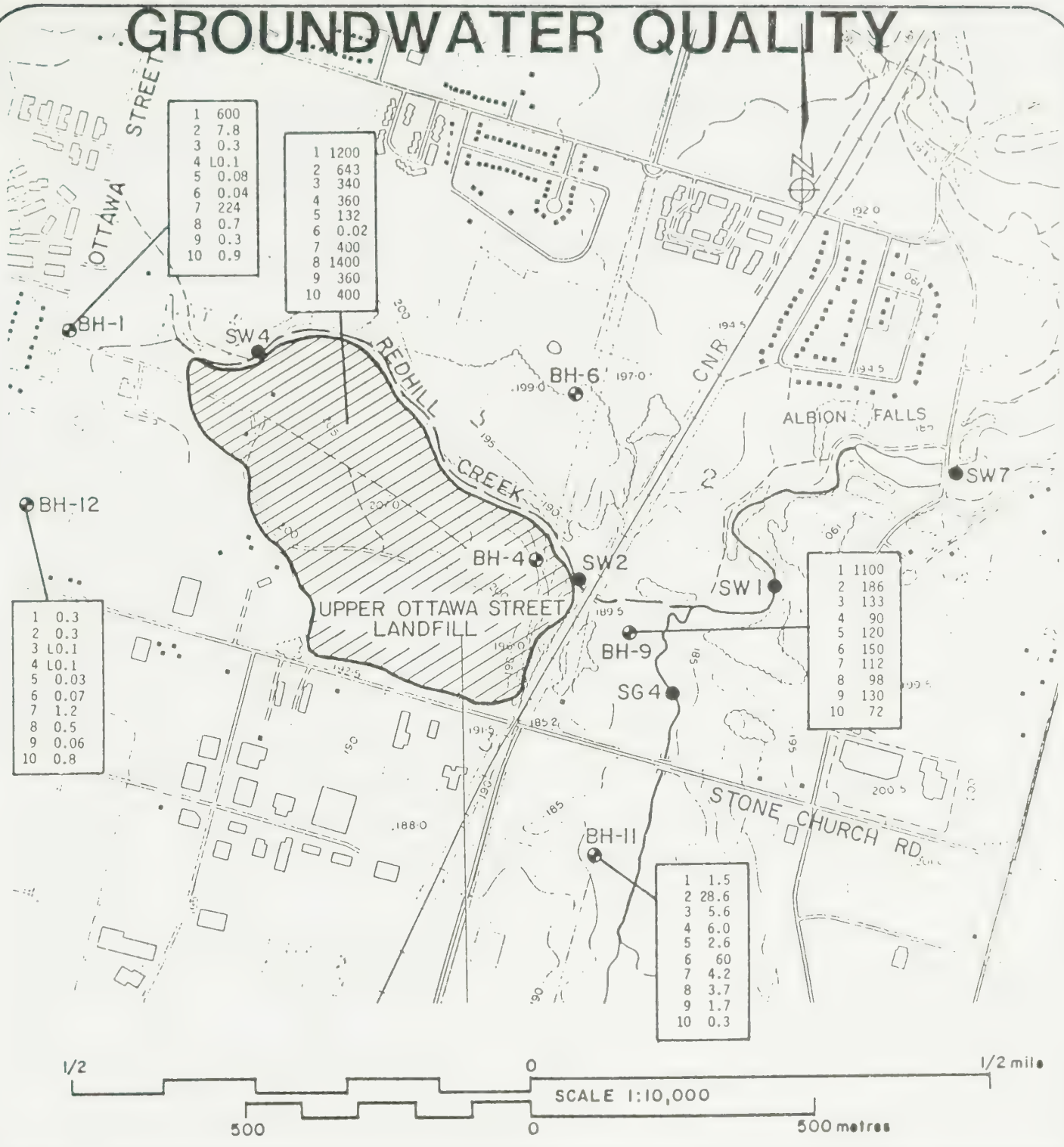
GROUNDWATER QUALITY



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UPPER OTTAWA STREET LANDFILL

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REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

AMMONIA mg/L

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TABLE 1

SUMMARY OF MONITORING WELL DETAILS

Well	Location	Water Level* (ft below surface)	Log (ft)
BH 1(I)	background, upgradient of landfill	28-30	0 - 10.0 clay silt till 10.0 - 25.0 dolostone (Goat Island) 25.0 - 31.7 dolostone (Gasport) 31.7 - 35.0 shale (Rochester) 35.0 - 37.5 dolostone screen interval 35-37.5 ft bottom of seal = 35 ft
BH 9(I)	100 m downgradient of landfill	2- 6	0 - 5.0 clayey silt (lacustrine) 5.0 - 32.0 dolostone (Goat Island) screen interval 29-32 ft bottom of seal = 29 ft
BH 11(I)	300 m S-E of landfill	2- 6	0 - 11.5 clayey silt(lacustrine) 11.5 - 45.7 dolostone (Gasport) 45.7 - 51.0 shale (Rochester screen interval 47-51 ft (estimate) bottom of seal = 47 ft (estimate)
BH 12(I)	background, upgradient of landfill	not reported	0 - 2.0 clayey silt till 2.0 - 17.0 dolostone (Goat Island) 17.0 - 19.0 dolostone (Gasport) screen interval (not reported)

* Water level based on 1979-1980 monitoring by GLAL

A. Background Wells, BH 1-I and BH 12-I

BH 12-I is about half the depth of BH 1-I. The chemistry of each well reflects this difference in well depth. The deeper groundwater in BH 1-I is more mineralized than the shallow water in BH 12-I. Parameters such as sulphate and chloride are often 10 times higher at BH 1-I than at BH 12-I. The difference in chemistry indicates the deeper groundwater has been in contact with more gypsum and shale than the shallow water.

Some parameters occur at similar strengths in both wells. These include: alkalinity, nitrogen group, phosphorus, phenols, and the metals. The longer residence time in gypsum and shale bedrock has little affect on these parameters.

Some of the major ions in both background wells fluctuate in strength by up to a factor of 10. These include calcium, chloride and sulphate. Conductivity fluctuates in proportion to the three major ions. There is no correlation between the temporal variation in chemistry in each well and no evidence of change in chemistry. This indicates the changes are due to local pulses of "fresher" or "more mineralized" groundwater migrating through the aquifer system.

Both background wells contain parameters derived from organic matter in the bedrock. These include reduced nitrogen species (ammonia and Kjeldahl), bulk organics (BOD and COD) and phenols. Temporal variations in these parameters range from factors of 10 to 100. For example, COD in BH 1-I was 2 and 588 mg/L on the November 1984 and June 1986 sampling.

As with the inorganic parameters, the deepest well, BH 1-I, shows the highest bulk organics. But peak levels of this group of parameters do not occur at the same time that the major ions reach peak levels. This is shown by the following examples:

Well/Parameter	Sampling Date			
	84/11/06	85/06/06	85/09/12	86/06/23
BH 1-I				
Chloride, mg/L	2450	1552	1035	3893
COD, mg/L	2	294	51	588
BH 12-I				
Chloride, mg/L	250	60	770	285
COD, mg/L	29	74	13	45.6

Several of the parameters in the 1984-86 data do not compare with previous results and appear to be in error. These are listed below:

BH 12-I: conductivity for November 6, 1984 sample is 11,000 umhos/cm compared to normal range of 900 to 1700 umhos/cm; appears to be a typographical error

BH 1-I: free ammonia for November 6, 1984 sample is 224 mg/L, compared to usual values of less than 1 mg/L and a Kjeldahl value of 2 mg/L; appears to be a typographical error

phosphorus for November 6, 1984 sample is 42 mg/L, compared to usual values of less than 0.4 mg/L; appears to be a typographical error

iron for November 6, 1984 sample is 114 mg/L compared to usual values of less than 5 mg/L; appears to be a typographical error, or possibly the result of sediment in the sample

B. Downgradient Wells, BH 9-I and BH 11-I

As shown in Table 1, page 15, BH 9-I is screened in dolostone at a depth of 8.8 m (29 ft) and BH 11-I is screened in shale at a depth of 14.3 m (47 ft). A University of Waterloo well near BH 11-I (UW 14) shows that the shale continues to a depth of 21 m (69 ft). BH 9-I is located 100 m directly downgradient of the landfill. BH 11-I, however, is located 300 m from the landfill on the outer fringe of groundwater flow paths originating at the landfill.

BH 11-I

The presence of the thick shale at BH 11-I results in exceptionally high levels of calcium, chloride, sodium, sulphate and conductivity. The concentration of these parameters is 10 times the levels found in BH 1-I, where only one metre of shale was encountered. Temporal variations of up to 10 times occur in some parameters. For example, in the 1984 to 1986 sampling, sulphate ranges from 1466 mg/L (June, 1985) to 13,640 mg/L (November, 1984).

Alkalinity is the only parameter in the major ion group that is not elevated above levels in the background wells. It is found in the low 100's of mg/L, similar to both BH 1-I and BH 12-I. This shows that alkalinity is not affected by the shale bedrock.

Some heavy metals, such as chromium and nickel are higher in BH 11-I than other wells. The 1985 and 1986 chromium levels are all greater than 6 mg/L. The WRI study also found chromium levels up to 6 mg/L in the deeper bedrock.

BH 11-I has particularly high BOD (up to 210 mg/L) and COD (up to 1912 mg/L). These concentrations reflect the presence of dissolved organic matter which occurs naturally in most shales. The WRI study also found evidence of organic-rich shales which gave TOC/DOC levels of over 1000 mg/L. (These are not analyzed in the Region's monitoring.)

BH 9-I

The 1984 to 1986 conductivity results for BH 9-1 show a decreasing trend (8500 down to 3150 umhos/cm). This trend reflects a major reduction in sulphate over the same period (20,460 down to 1790 mg/L). A similar decreasing pattern occurred for suphates in 1982 to 1984 (see Figure 10); but that change did not have much affect on the conductivity. Chloride, calcium and sodium seldom vary by more than a factor of two. Therefore, they should not have much affect on conductivity.

Two parameters occur at higher levels in BH 9-1 than in any other well; alkalinity and the reduced nitrogen species, free ammonia and Kjeldahl nitrogen. Alkalinity ranges from about 500 to over 1500 mg/L. Background alkalinity is usually less than 300 mg/L. Free ammonia is usually found between 70 and 200 mg/L, compared to background levels of less than 10 mg/L. Kjeldahl nitrogen fluctuates from 35 to 1400 mg/L compared to background levels of of less than 30 mg/L.

Parameters such as phenol, phosphate, PCB and the heavy metals are not elevated in BH 9-1 above normal background levels. The hardness is slightly higher than in the dolostone at BH 1-I, but much lower than in the shale at BH 11-I. The pH in BH 9-I is similar to the other wells.

2.4 Combustible Gas

The gas probe monitoring data is summorized in Appendix F. No combustible gases were detected in any of the nine monitoring probes or Quonset hut during the 1984 to 1985 monitoring period.

3.0 IMPACT ASSESSMENT

3.1 Surface Water

The monitoring shows that a small quantity of landfill-derived leachate is entering Redhill Creek. This impact increases the strength of some inorganic parameters (e.g., chloride) by about 10%. Other parameters such as BOD, phenol and PCB show erratic fluctuations, often unrelated to the landfill. Ammonia appears to have the greatest consistant impact. During low-flow periods the un-ionized ammonia probably exceeds the MoE water quality objectives of 0.02 mg/L. Iron is not affected by the leachate.

Leachate constituents enter Redhill Creek by two routes: overland flow from seepages and via the groundwater flow. The chemical concentrations in the leachate seepages should be considerably higher than in the groundwater flow. The latter should be diluted by flow in the subsurface dolostone bedrock.

Streamflow gauging in September 1985 suggests groundwater discharge to the creek from beneath the landfill was about 0.5 L/s. This represents about 3% of the streamflow at that time. The September flow should be typical of conditions in the seasonal low-flow period.

The impact of the landfill on Redhill Creek is largely dependent on the dilution that is available. Previous monitoring shows spring and fall flows are at least 10 times greater than we measured in September. It is unlikely that leachate seepage and groundwater discharge beneath the landfill would increase by more than about 5 times. Thus, it appears that the worst-case impact on Redhill Creek would occur during low-flow conditions.

The effect of flow conditions on the stream can be seen by comparing water quality data. Table 2 lists some of the chemical results for the three dates that flows were measured. While the data does not show significant seasonal variation in water quality, the low-flow data is generally higher in chemical loading. It is noted that the upstream station (SW 4) also shows higher chemical loading during the low-flow period than during the high-flow periods.

The strength of leachate constituents entering Redhill Creek can be estimated from mass balance calculations. The mass balance for the reach of the stream between stations SW 2 and SW 4 is as follows:

$$(Q \times C)_{SW4} + (Q \times C)_{LS} + (Q \times C)_{GWL} + (Q \times C)_{GWE} = (Q \times C)_{SW2}$$

where: Q = flow, L/s
C = concentration, mg/L
LS = landfill seepage
GWL = groundwater discharge, landfill side
GWE = groundwater discharge, east side
SW4 = upstream station
SW2 = downstream station

The above equation can be used to estimate concentration of chemicals entering the creek from the landfill. For example, calculations for chloride input on September 11, 1985 are as follows:

$$14(180) + 1(C) + 0.5(C) + 0.5(200) = 16(200)$$

$$1.5(C) = 3200 - 2520 - 100$$

$$C = \frac{580}{1.5} = 390 \text{ mg/L}$$

TABLE 2

SUMMARY OF SURFACE WATER QUALITY VS. STREAMFLOW

	Nov. 11/83		May 10/84		Sept. 11/85	
Chemical Parameter	SW 4 (196 L/s)	SW 1 (429 L/s)	SW 4 (179 L/s)	SW 1 (415 L/s)	SW 4 (14 L/s)	SW 2 (16 L/s)
Conductivity (umhos/cm)	800	750	900	850	1100	1200
Chloride (mg/L)	155	185	118	108	200	215
Kjeldahl N (mg/L)	0	0.4	2.5	N.D.	0.7	3.8
Ammonia (mg/L)	0.1	0.4	0.2	0.3	0.4	1.2
Iron (mg/L)	0.2	0.5	0.1	0.2	0.3	0.4
BOD (mg/L)	13	13	50	5	65	4.5

Notes:

SW 2 (downstream of landfill)
was not sampled in November 1983 and May 1984.

SW 1 is downstream of a tributary stream;
Gartner Lee indicate SW 1 flows were inaccurate;
actual flows were probably closer to 300 L/s.

In this calculation, it is assumed that the chloride concentration in groundwater entering the stream from the opposite side of the landfill is 200 mg/L. This compares with shallow groundwater analyses in the WRI studies. Also, it was assumed that the concentration of the leachate seepage and the groundwater discharge beneath the landfill is the same. In actual fact, the latter should be more dilute.

The mass balance calculation suggests the leachate reaching the creek is much weaker than leachate in the collector system (i.e., at the manhole). This indicates that the leachate is significantly attenuated by dilution and othe processes before discharging to the creek.

In summary, the landfill does not significantly impact Redhill Creek for the following reasons:

- contaminant loading of the leachate appears to be relatively low
- dilution in the creek probably ranges from about 10 in the low-flow period to over 20 in the high-flow periods

Of the parameters monitored, only four are likely to occassionlly exceed MoE water quality objectives: un-ionized ammonia, PCB, phenols and iron. These parameters could marginally exceed the objectives during low-flow periods in the summer and fall.

3.2 Groundwater

Our review of both the Region of Hamilton-Wentworth monitoring and the WRI study shows the landfill has caused a minor impact on groundwater near the site. Evidence of the impact emerges from examination of long-term temporal variation in the groundwater chemistry (from the Region's monitoring) and the more comprehensive "snap shot" monitoring by WRI. Previous studies of the groundwater quality were inconclusive, mainly due to the complex chemistry and temporal variation.

The best indicators of landfill-derived contamination are alkalinity and the reduced nitrogen species (ammonia and Kjeldahl nitrogen). These parameters do not appear to be affected very much by differences in the shale and dolostone chemistry but are found at high levels in the leachate. The usual leachate indicators, such as chloride, sulphate and the organic parameters (COD, BOD) fluctuate dramatically in most of the monitoring wells.

Of the wells monitored by the Region, only BH 9-I shows a landfill-derived impact. Alkalinity in this well is up to 5 times the normal background level. Ammonia and Kjeldahl nitrogen are up to 50 times background levels. The results of the WRI study also confirm that alkalinity and the two nitrogen species are the best leachate indicators.

Groundwater moving through and beneath the landfill transports some leachate constituents away from the site. The WRI study indicates the main movement is eastward via the surficial dolostone bedrock. Minor movement may occur out from the edge of the landfill in other directions due to mounding of the water table in the site. However, the upgradient flow should be limited to a few metres. The WRI study shows the shale has a hydraulic conductivity that is 1000 to 10,000 times lower than that of the dolostone. Therefore, while a minor amount of leachate may migrate downward via vertical fractures in the shale, the quantity would be relatively small.

The WRI study generally identified the limits of the leachate mixing zone in the dolostone. The study concludes that the primary affected area is limited to an area within 100 m of the landfill (on the downgradient or eastward side). BH 9-I is probably located near the core of the leachate mixing zone. It is a little over 100 m from

the landfill. It is estimated that the leachate mixing zone may extend up to 200 or 300 m east or northeast of the landfill. Beyond that, it is expected that the few traceable indicators would be attenuated to non-detectable levels.

3.3 General Landifll Conditions

Our reconnaissance study of the landfill focussed on three areas of interest: i) vegetation stress ii) surface erosion and iii) leachate seepage. Map 1 (in the map pocket) locates each of the affected areas as determined by the field inspection.

Areas of vegetation stress usually indicate thin cover, where venting of landfill gases reduces the soil oxygen content. Areas of poor vegetation cover are more easily eroded and may be the cause of a few broad areas of surface erosion.

Erosion channels are common near the tow of long, steep landfill slopes. Leachate seepage, as discussed previously, indicates a mounded water table in the landfill.

4.0 CONCLUSIONS

The following conclusions are based on our review of the 1984 to 1986 monitoring data and the WRI study.

1. The quality of leachate at the Upper Ottawa Street landfill is typical of sites undergoing active decomposition. There is no indication of an overall decay in leachate strength. A gradual decay should begin within the next 10 to 20 years.

2. Leachate seepage from the toe of the landfill causes a minor impact on Redhill Creek during periods of low flow. A few parameters may occassionally exceed the MoE water quality objective in the reach of the stream opposite the landfill. The impact of the leachate is generally not evident at SW 1 (350 m downstream of landfill) and at SW 7 (near Albion Falls).

3. Leachate emanating from the landfill also causes a minor impact on groundwater near the site. The effect is mainly an increase in alkalinity and in the reduced nitrogen species (ammonia and Kjeldahl nitrogen). BH 9-I is the only well monitored by the Region that shows increased levels of the three parameters. Four or five of the WRI wells close to the landfill also showed the same elevated parameters.

4. The leachate mixing zone appears to extend east or northeast of the landfill and is limited mainly to the dolostone bedrock. Any contaminant movement in other directions or downward into the shale bedrock should be minor and of no concern. No water resources are threatened by the groundwater impact.

5. There does not appear to be any concern about lateral migration of methane from the landfill. It may be a concern, however, in the leachate collection system, where it could accumulate in the manholes.

6. Our site inspection in 1985 identified some areas where site maintenance is needed. The work required involves regrading a few erosion channels and revegetating some areas on the outer sideslopes of the landfill.

5.0 RECOMMENDATIONS

After five years of routine site monitoring by the Region and completion of the comprehensive WRI study, it is in order to modify the monitoring program. The changes are based on the confirmed absence of significant impacts at this site. The following program is suggested for the next two or three years.

1. Surface Water

Sampling Stations:
- SW 1, SW 2, SW 4, SW 7 and the tributary between SW 1 and SW 2
- SW 1 appears to be opposite an old section of landfill; it should be relocated 200 to 300 m upstream to be certain that background conditions are monitored at this station

Sampling Frequency:
- three times per year during the low-flow period (June to September)

Water Analyses:
- (same as before) pH, conductivity, chloride, ammonia and Kjeldahl nitrogen, iron, phenol, BOD and PCB

2. Groundwater

Wells:
- BH 1-I, BH 9-I and BH 9-II
- BH 12-I and BH 11-I do not represent typical background water quality at the site and should be dropped from the monitoring program
- BH 9-II is added as it is a shallower well than BH 9-I and may be useful in monitoring leachate impacts in the dolostone bedrock

Sampling Frequency: - once per year (the previous monitoring established the temporal variation in water quality; in the future, long-term trends for the leachate indicators are needed and these will develop very slowly)

Water Analyses: - pH, conductivity, hardness, alkalinity, chloride, sulphate, iron, ammonia and Kjeldahl nitrogen, nitrate, phenol, BOD, COD, TOC, and PCB

3. Leachate

Manholes: - MH 1

Sampling Frequency: - once per year

Water Analyses: - same as groundwater

4. Combustible Gas

- there is no need to monitor the gas probes, but monitoring of the manholes is recommended; the manholes should be monitored monthly from January to April to establish the worst-case condition

5. Stream Sediment

- not recommended

6. Streamflow

- not recommended

7. Site Inspections

- annual site inspection in June for:
  - vegetation stress
  - erosion
  - leachate seepage

8. Site Maintenance

- regrade all eroded areas and channels
- revegetate areas of grass-kill and erosion as required; add additional topsoil if necessary to establish hardy growth.

Respectfully submitted,
MORRISON BEATTY LIMITED

Brian W. Beatty, P.Eng.

APPENDIX A

LEACHATE CHEMISTRY, 1981-1986

PROJECT UPPER OTTAWA STREET LANDFILL SHEET 1

WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 REMARKS REGION OF HAMILTON-WENTWORTH

PROPERTY		Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984	Nov. 6 1984	June 6 1985	Sept.12 1985	June 6 1986	
CONDUCTIVITY μMHOS/CM.		10,000	15000	15000	10900	7500	9000	14800	7000	7000	4400	
pH		7.55	8.29	7.6	8.1	7.9	8.1	8.0	8.5	8.3	8.3	
HARDNESS ($Ca CO_3$)		1250	-	1275	1300	1080	1270	744	1000	670	1164	
ALKALINITY ($Ca CO_3$)												
CHLORIDE (Cl)		60	75	3000	28.50	3150	1750	3200	2405	45	555	
SULPHATES (SO_4)		300	225	5200	160	600	100	2592	153	78	2046	
PHOSPHOROUS AS P	Total	2.0	6.8	2.5	4.29	3.5	2.8	66	0.85	4.5	3.8	
	Soluble											
NITROGEN (N)	Total Kjeldahl	1200	6.43	396	540	95	11.2	700.0	-	320	1900	
	Free Ammonia	1200	643	340	360	132.5	0.02	400	1400	360	400	
	Nitrite ug/L	-	-	-	1.0	ND	2.9	0.9	0.50	2.73	0.03	
	Nitrate	-	-	7.3	1.6	-	-	0.70	6.0	-	0.60	
METALS	Chromium (Cr)	ND	ND	0.50	0.11	0.10	ND	not Detect	0.38	0.41	0.5	
	Copper (Cu)	0.1	0.1	0.33	0.40	ND	0.04	0.02	0.04	0.03	0.03	
	Zinc (Zn)	0.1	0.2	0.28	0.11	0.16	0.10	0.27	0.05	0.09	0.1	
	Nickel (Ni)	0.3	0.3	0.24	0.23	0.17	0.12	0.3	0.19	0.2	0.7	
	Iron (Fe)	1.5	2.7	7.7	4.2	4.5	7.2	26	1.67	6.0	5.12	
BOD		286	696	129	119	620	560	327	307	232	126	
Total Dissolved Solids		8736	-	10108	9282	6640	6140	8972	17696	20952	8720	
COD		2132	4706	1801	96	956	941	2310	3677	1071	2941	

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT UPPER OTTAWA STREET LANDFILL SHEET 2

WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 TESTED BY REGION OF HAMILTON-WENTWORTH

	Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984	Nov. 6 1984	June 6 1985	Sept.12 1985	June 6 1986	
Dissolved Oxygen	801	-	4.5	7.1	-	2.6	1.0	-	-	1.1	
Phenol ug/L	331	156	281	80	1.38	-	7.14	79.59	0.05	17.8	
PCB ug/L	2.1	3.0	-	-	<0.004	-	0.28	0.48	0.09	1.2	
Total Coliform/100ml	5000±	800	1800	2500	-	-	-	-	-	-	
Fecal Coliform/100ml	10	100	0	45	-	-	-	-	-	-	

NOTE: concentrations in p.p.m. unless otherwise noted.

APPENDIX B

STEAM GAUGING RECORDS, 1981-1986

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

UPPER OTTAWA STREET LANDFILL - 1984 - 1985 ANNUAL MONITORING REPORT

STREAM GAUGING STATION SW 4 . Red Hill Creek at the North west end of Landfill just downstream of bedrock exposure

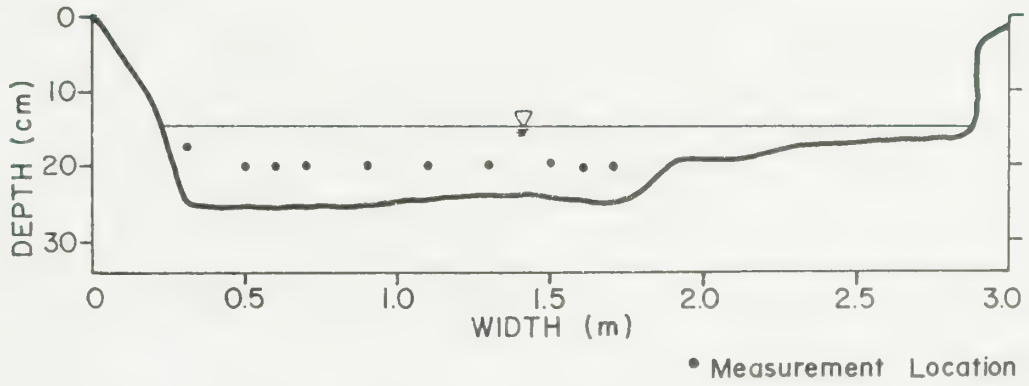
DATE September 12, 1985

FLOW RATE 14.2 L/s

METHOD A Ott Meter

FLOW CONDITIONS Bottom hard, some bedrock exposure

STREAM PROFILE:



REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
UPPER OTTAWA STREET LANDFILL - 1984 - 1985 ANNUAL MONITORING REPORT

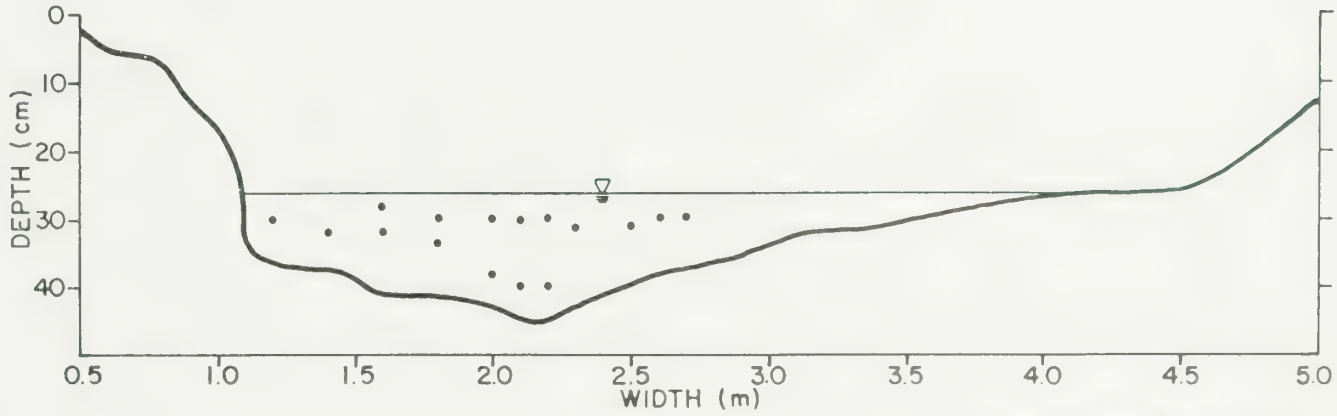
STREAM GAUGING STATION SW 2. Red Hill Creek, Eastern limit of Landfill, ± 20m west of CNR tracks

DATE September 12, 1985 FLOW RATE 16.1 L/s

METHOD A Ott Meter

FLOW CONDITIONS Bottom soft with larger stones, turbulent flow

STREAM PROFILE:



• Measurement Location

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
UPPER OTTAWA STREET LANDFILL - 1984 - 1985 ANNUAL MONITORING REPORT

STREAM GAUGING STATION SG 4 . Tributary to Red Hill Creek

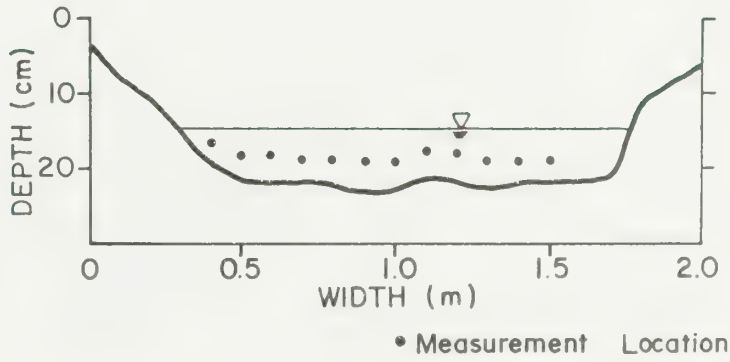
concrete channel downstream of Stone Church Road, 200m west of CNR tracks

DATE September 12, 1985 FLOW RATE 10.1 L/s

METHOD A Ott Meter

FLOW CONDITIONS Concrete channel overgrown with weeds, turbulent flow

STREAM PROFILE:



REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
UPPER OTTAWA STREET LANDFILL - 1984 - 1985 ANNUAL MONITORING REPORT

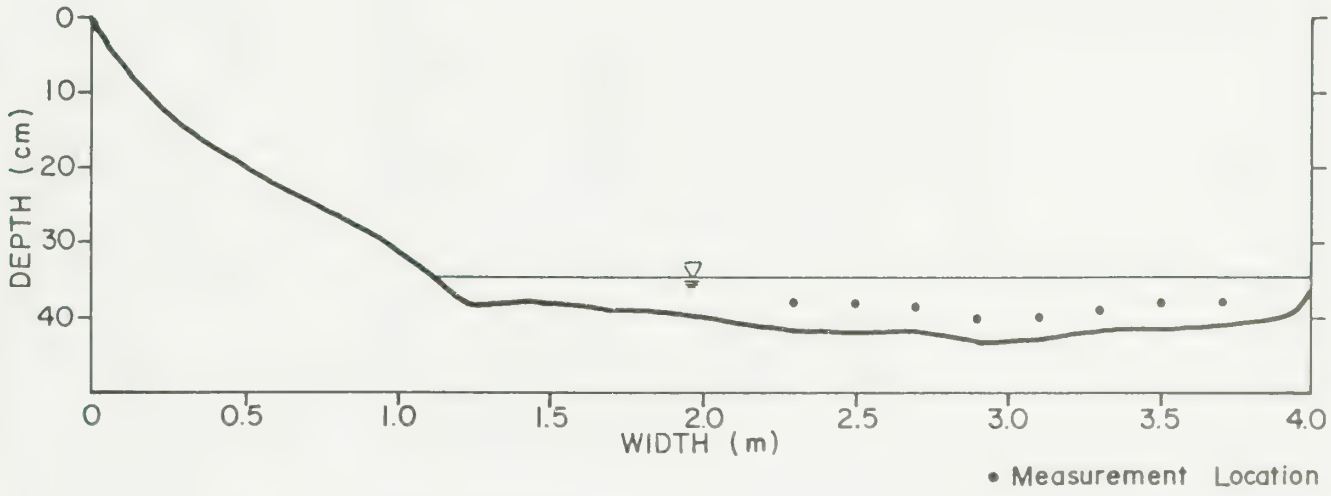
STREAM GAUGING STATION SW 1 . Red Hill Creek, concrete channel, 400m downstream of CNR tracks

DATE September 12, 1985 FLOW RATE 26.6 L/s

METHOD A Ott Meter

FLOW CONDITIONS Turbulent flow

STREAM PROFILE:



REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
UPPER OTTAWA STREET LANDFILL - 1984 - 1985 ANNUAL MONITORING REPORT

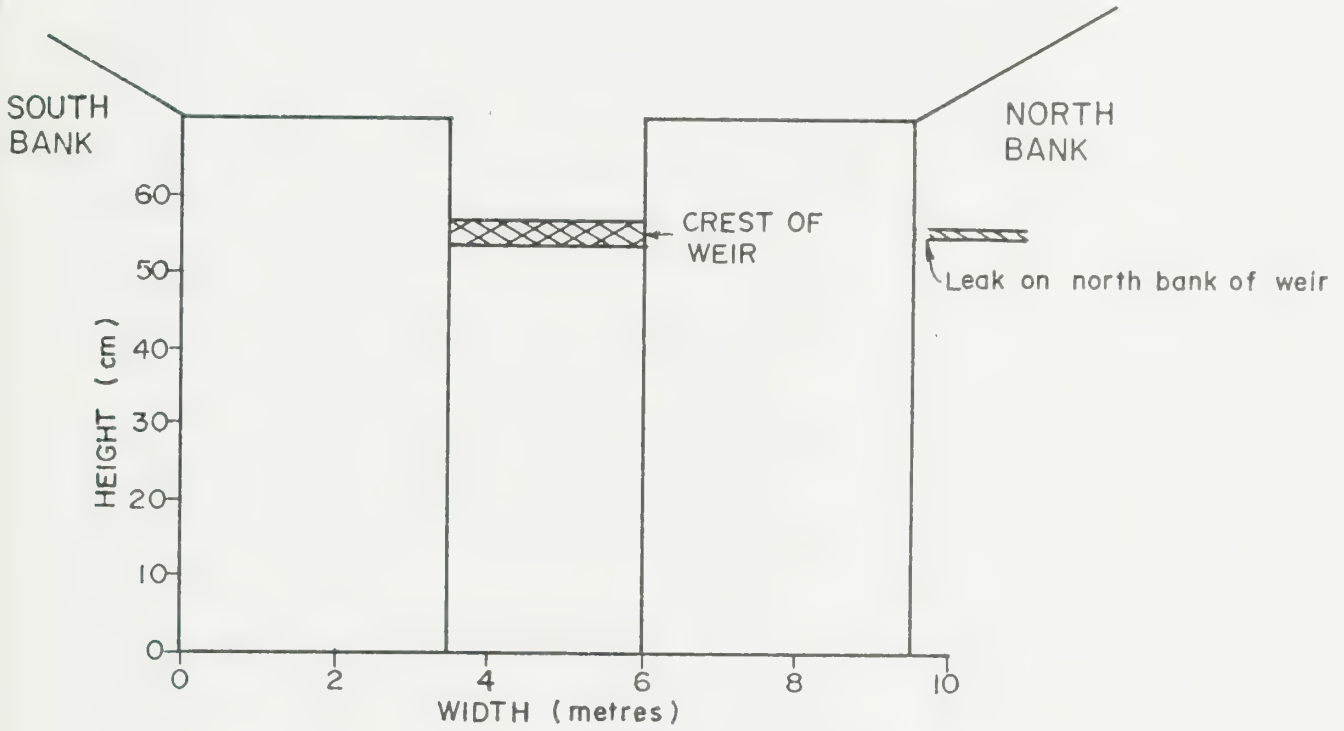
STREAM GAUGING STATION SW 7 . Weir at Albion Falls just east of Mud Street

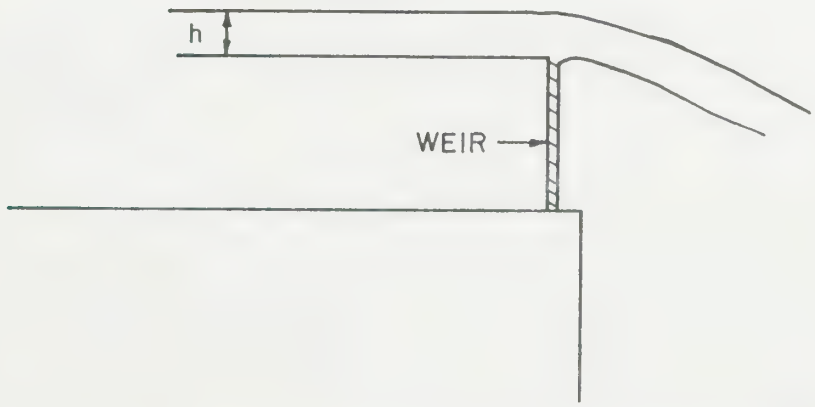
DATE September 12, 1985 FLOW RATE 27.6 L/s

METHOD

FLOW CONDITIONS

TEST SECTION:





N.T.S.

APPENDIX C

SURFACE WATER CHEMISTRY, 1981-1986

PROJECT UPPER OTTAWA STREET LANDFILL SHEET 2

WATER ANALYSIS RESULTS

SAMPLING LOCATION Surface Water Station SW2 TESTED BY REGION OF HAMILTON-WENTWORTH

PARAMETER \ DATE	Nov 26 1981	June 3 1982	Dec 8 1982	Nov. 6 1984	June 6 1985	Sept.11 1985	June 23 1986				
Conductivity(umhos/cm)	1200	1550	1050	13200	1350	1200	470				
pH	7.7	8.17	8.0	7.7	7.9	6.8	7.55				
Chloride	125	205	115	185	218	215	220				
tot.Kjeldahl Nitrogen	3.0	3.4	0.4	4.0	10.0	3.8	3.5				
Iron	<0.1	-	0.10	0.7	0.05	0.4	-				
BOD	5.1	3.0	2.7	5	255	4.5	0				
Ammonia	2.4	1.9	<0.1	3.20	2.9	1.16	0.29				
Phenol(ug/l)	25	0	not Detect	not Detect	11.22	0.04	0.9				
PCB (ug/l)					0.06	not Detect	6.0				

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT UPPER OTTAWA STREET LANDFILL

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW4 TESTED BY REGION OF HAMILTON-WENTWORTH

Date / PARAMETER	Nov 26 1981	June 3 1982	Dec 8 1982	June 7 1983	Nov 11 1983	May 10 1984	Nov. 6 1984	June 6 1985	Sept.11 1985	June 23 1986	
Conductivity(umhos/cm)	1050	1400	1000	910	800	900	12100	1200	1100	900	
pH	7.6	8.6	7.7	7.4	7.5	7.5	7.8	7.9	7.0	7.4	
Chloride	85	65	95	92	155	118	145	172	200	195	
tot.Kjeldahl Nitrogen	0.8	0.4	<0.10	<1.0	0	2.48	6.0	9.0	0.7	2.0	
Iron	0.2	-	<0.10	0.10	0.24	0.13	0.7	0.1	0.3	-	
BOD	4.6	-	2.2	2	13	50	5	90	65	0	
Ammonia	0.35	0.1	<0.1	<0.1	0.07	0.18	0.88	0.16	0.40	0.50	
Phenol (ug/L)	14	0	not Detect	15	0.04	0	not Detect	4.08	0.05	1.0	
PCB (ug/L)								0.04	not Detect	0.6	

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT UPPER OTTAWA STREET LANDFILL

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW7 TESTED BY REGION OF HAMILTON-WENTWORTH

PARAMETER \ Date	Nov 26 1981	June 3 1982	Dec 8 1982	June 7 1983	Nov 11 1983	May 10 1984	Sept.11 1985	June 23 1986			
Conductivity(umhos/cm)		1520				900	1000	870			
pH		8.22				7.6	7.1	6.0			
Chloride		19				112	195	112			
tot.Kjeldahl Nitrogen		44				0.52	not Detect	-			
Iron		-				0.15	1.1	-			
BOD		2.0				40	362	-			
Ammonia		2.1				0.32	0.34	-			
Phenol (ug/L)		0				0	0	-			
PCB (ug/L)							0.06	0.7			

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT UPPER OTTAWA STREET LANDFILL

SHEET 5

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION TRIBUTARY TESTED BY REGION OF HAMILTON-WENTWORTH

PARAMETER \ DATE	June 6 1985	Sept.11 1985	June 23 1986								
Conductivity(umhos/cm)	1000	1000	870								
pH	8.0	7.0	6.0								
Chloride	149	145	112								
tot.Kjeldahl Nitrogen	606	not Detect	-								
Iron	0.04	0.3	-								
BOD	85	97	-								
Ammonia	0.4	0.24	-								
Phenol(ug/l)	5.1	-	-								
PCB (ug/l)	0.07	not Detect	0.7								

NOTE: concentrations in p.p.m. unless otherwise noted.

APPENDIX D

PCBs IN STREAM SEDIMENTS, 1979-1985

UPPER OTTAWA STREET LANDFILL

PCB IN SEDIMENT SAMPLE

		Oct.31 1979	Nov.25 1980	June 3 1982	Nov.30 1983	Nov.6 1984	June 6 1985	June 23 1986
STATION	SW 1	Not Sampled	0.017	0.025	0.034	.037	.090	.040
	SW 2	244	0.90	Not Sampled	Not Sampled	-	.040	.008
	SW 4	662	0.39	0.024	0.018	.012	.080	.030
TRIBUTARY		Not Sampled	Not Sampled	Not Sampled	Not Sampled	Not Sampled	.020	.030

NOTES:

1. Concentration expressed in ug/g (microgram/gram)
2. Oct. 31, 1979 Analysis by Peninsula Chemical Analysis
3. Nov. 25, 1980 Analysis by Beak
4. June 3, 1982, Nov. 30, 1983, Nov. 6, 1984, June 6, 1985, and June 23, 1986 analysis supplied by Region.

APPENDIX E

GROUNDWATER CHEMISTRY, 1981-1986

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH1-I

SHEET: 1

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	850912	860623
Conductivity	2800	9000	6500	1100	3000	11000	7000	2520	2300	4500
pH	6.9	7.7	6.9	6.75	7.2	7.3	7.0	7.0	7.1	7.4
Hardness	1700	238	1275	1320	1140	2010	2240	1059	890	1530
Alkalinity	380	334	255	244	280	245	282	268	280	250
Chloride	140	2500	1983	5400	900	4050	2450	1552	1035	3893
Tot. Kjeldahl	700	710	0.86	1.34	0.08	0.76	2.0	2.5	2.6	1.7
Calcium	350	117	375	960	130	700	530	*1	229	552
Free Ammonia	600	7.85	0.30	<.10	0.08	0.04	224	0.7	0.28	0.90
Nitrate	*	*	5.0	0.19	ND	0.4	0.20	0.15	0.20	0.05
Nitrite ug/L	*	*	4.0	2.6	74	6.0	0.25	-	ND	0.06
Phenol ug/l	0	0.20	3.07	156	0.08	0	ND	6.12	0.06	0.06
BOD	86	156	5.7	ND	11	20	11	98	360	90
COD	220	294	118	341	29	397	2	294	51.5	588
Sulphate	9773	2750	8750	625	685	950	8184	784	852	767
Phosphate	-	-	-	-	-	-			0.18	0.02
Phosphorous	0.24	0.10	0.15	0.39	0.01	0.05	42.0	0.05	-	-
PCB ug/l						<0.04	0.32	0.19	0.37	0.4
Chromium	ND	ND	0.21	0.04	0.04	ND	ND	0.72	0.43	0.63
Copper	0.2	1.2	0.18	0.06	ND	0.05	0.04	0.07	0.02	0.02
Iron	1.4	0.5	4.9	2.20	0.40	<.10	114	0.47	1.9	1.75
Nickel	<.1	ND	<110	0.08	ND	<.10	0.1	0.08	ND	0.4
Zinc	<1	0.03	0.10	2.78	0.02	ND	1.83	0.75	0.04	0.16
Tot. Coliform	70	50	0	270						
Fecal Coliform	10	0	0	0						
Sodium	420	2050	1035	3230	550	2320	1300	*1	660	2840

* strong colour, prevented analysis

*1 insufficient sample

ND not detected

TEST SET GROUP G-B

GROUND WATER MONITOR BH 4-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	860623
Conductivity	14000	13200							
pH	7.7	7.88							
Hardness	700	309							
Alkalinity	6580	308							
Chloride	60	400							
Tot. Kjeldahl	1600	697							
Calcium	35	30							
Sodium	3300	1950							
Free Ammonia	1500	499.8							
Nitrate	*	*	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
Nitrite	*	*							
Phenol ug/l	1579	26							
BOD	986	218							
COD	4706	3162							
Sulphate	600	975							
Phosphate	-	-							
Phosphorous	6.0+	4.3							
PCB									
Chromium	ND	ND							
Copper	3.0	7.2							
Iron	5.5	6.4							
Nickel	0.3	0.3							
Zinc	0.4	0.07							
Tot. Coliform	0	900							
Fecal Coliform	0	80							

* Strong colour, prevented analysis
\+ Result unreliable, probably high
ND not detected

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 6-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	850912	860623
Conductivity	-	11500								
pH		7.5								
Hardness		391								
Alkalinity		94								
Chloride		280								
Tot. Kjeldahl		19								
Calcium		1125								
Sodium		1500								
Free Ammonia		5.0								
Nitrate		*								
Nitrite		*								
Phenol ug/l		0								
BOD	Dry	5.75	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
COD		279								
Sulphate		1800								
Phosphate										
Phosphorous		0.14								
PCB										
Chromium		ND								
Copper		1.5								
Iron		1.5								
Nickel		ND								
Zinc		.01								
Tot. Coliform		0								
Fecal Coliform		0								

* Strong colour, prevented analysis
ND not detected

UPPER OTTAWA STREET

SHEET: 4

TEST SET GROUP G-B

GROUND WATER MONITOR BH 9-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	850912	860623
Conductivity	6000	8100	8000	5800	6500	7500	8500	3700	3700	3150
pH	6.5	7.38	6.5	6.8	6.8	7.1	7.2	6.7	7.3	7.6
Hardness	2500	234	2872	3060	2000	2130	1930	1250	2670	2817
Alkalinity	1490	183	1500	1570	500	1310	1212	634	1340	1320
Chloride	1350	4250	1523	1690	1715	4100	1900	1498	1875	2715
Calcium	625	107	840	2910	700	600	780	*1	507	690
Sodium	1150	1000	810	1230	1000	1130	1460	*1	960	1080
Free Ammonia	1100	186	133	90	120	150	112.5	98	130	72.5
Nitrate	0.14	*	17.0	0.05	1.1	0.6	1.0	0.85	0.85	0.1
Nitrite ug/l	0.0	*	*	6.0	*	2.0	1.1	0.2	ND	0.08
Phenol ug/l	21	22	12.28	56	0.20	0	ND	10.2	0.05	2.8
BOD	31	36	32	54	28	35	35	253	150	21
COD	485	515	471	441	529	603	3	368	388	382
Sulphate	8523	1950	17200	200	3000	1370	20460	2148	1944	1790
Phosphate									0.25	0.02
Phosphorous	ND	0.13	0.12	0.26	0.14	0.15	0.13	0.01		
PCB ug/l						<0.04	0.12	0.04	ND	0.5
Chromium	ND	ND	0.15	ND	0.05	ND	ND	0.75	1.02	0.94
Copper	<.1	1.0	<.10	0.05	ND	0.02	0.02	0.06	0.03	0.02
Iron	0.3	0.5	0.38	0.10	0.30	0.28	3.0	0.25	0.5	0.23
Nickel	0.1	ND	<.10	0.07	0.07	<.10	0.2	0.05	ND	0.60
Zinc	ND	<.01	0.05	0.01	0.03	ND	0.02	0.07	0.02	0.01
Tot. Coliform	210	200	10	0						
Fecal Coliform	0	0	0	0						
tot. Kjeldahl	1100	221.34	133	123	210	54.4	1400	35.0	250	104

* Strong colour, prevented analysis

*1 insufficient sample

ND not detected

TEST SET GROUP G-B

GROUND WATER MONITOR BH 11-I

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	850912
Conductivity	12000	11800	20500	13500	15000	26000	39800	24000	11000
pH	6.5	7.8	6.8	6.9	6.9	7.5	7.3	6.9	7.4
Hardness	5360	393	7358	8600	6150	10000	14720	5802	18700
Alkalinity	260	304	300	324	170	279	164	54	240
Chloride	5570	3650	8305	7600	7750	12300	18300	22150	104000
tot.Kjeldahl	4.60	21	5.7	6	5.2	7.2	16.5	17.0	10.5
Calcium	900	875	2170	4400	1900	2670	4000	*1	3717
Sodium	2000	1500	2380	3800	2700	4000	8600	*1	5500
Free Ammonia	1.50	28.6	5.6	6	2.6	60	4.16	3.7	1.74
Nitrate	*	*	<0.1	0.55	ND	1.1	-	0.1	0.14
Nitrite ug/l	*	*	6.0	2.6	*	*	0.8	0.4	ND
Phenol ug/l	7	18	ND	102	ND	0	ND	10.2	0.06
BOD	123	125	147	126	124	140	69	33	210
COD	625	809	882	515	794	1118	3	1912	765
Sulphate	1652	1275	46400	540	1800	1000	13640	1466	2155
Phosphate									0.10
Phosphorous	ND	0.21	0.04	0.13	0.02	0.06	0.07	ND	
PCB ug/l						<0.04	0.82	0.08	ND
Chromium	ND	ND	0.40	0.15	0.05	ND	ND	6.7	8.1
Copper	<.1	1.3	0.13	0.04	ND	0.04	0.04	0.08	0.13
Iron	0.1	1.1	0.53	0.21	0.46	0.25	2.7	0.47	0.9
Nickel	0.2	ND	0.10	0.12	0.12	0.12	0.5	0.47	0.2
Zinc	ND	0.05	0.11	0.04	0.04	0.05	0.12	0.09	0.1
tot. Coliform	10	7600	0	11					
Fecal Coliform	0	30	0	0					

* strong colour, prevented analysis
*1 insufficient sample
ND not detected

TEST SET GROUP G-B

GROUND WATER MONITOR BH 11-I

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	860623
Conductivity	9000
pH	7.6
Hardness	9400
Alkalinity	305
Chloride	-
tot.Kjeldahl	2.15
Calcium	7060
Sodium	8200
Free Ammonia	0.34
Nitrate	0.30
Nitrite ug/l	0.06
Phenol ug/l	0.90
BOD	239
COD	2382
Sulphate	1423
Phosphate	0.14
Phosphorous	-
PCB ug/l	-
Chromium	6.0
Copper	0.1
Iron	1.08
Nickel	2.3
Zinc	0.13
tot. Coliform	-
Fecal Coliform	-

* strong colour, prevented analysis
*1 insufficient sample
ND not detected

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR:BH 12-1

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	811127	820603	821208	830607	831130	840510	841106	850606	850912
Conductivity	1200	1410	1150	1390	900	1700	11000	700	1600
pH	6.9	8.15	6.8	7.3	7.0	7.6	7.3	7.2	7.1
Hardness	6900	594	545	860	920	730	790	810	710
Alkalinity	260	32.6	275	280	370	248	274	271	300
Chloride	250	100	161	332	605	500	250	60	770
tot. Kjeldahl	30	1.9	<.1	<1.0	0.03	ND	1.2	1.7	ND
Calcium	200	312	144	620	145	200	300	*1	170
Sodium	135	430	63	240	275	120	86	*1	440
Free Ammonia	0.30	0.27	<.1	<.1	0.03	0.07	1.20	0.52	0.06
Nitrate	0.08	*	2.0	0.30	0.10	ND	0.40	0.45	0.06
Nitrite ug/l	0.001	*	2.0	4.0	2.0	6.0	0	0.1	0.01
Phenol ug/l	0	0	60.1	ND	0.04	0	ND	10.2	0.19
BOD	3	5.50	2.1	1	12	50	7	100	47
COD	73	56	17.6	382	4	20	29	74	13
Sulphate	400	2500	1700	260	250	205	1910	153	249
Phosphate									0.04
Phosphorous	0.14	0.31	0.03	<.01	0.01	0.05	0.08	ND	
PCB ug/l						<0.04	0.21	0.04	ND
Chromium	ND	ND	<.10	0.04	ND	ND	ND	0.24	0.29
Copper	0.2	1.2	<.10	ND	ND	0.03	0.02	0.02	0.02
Iron	2.8	53	0.52	0.85	0.34	0.78	4.2	0.43	0.3
Nickel	<.1	ND	<.10	0.02	ND	<.10	<.1	ND	ND
Zinc	0.8	1.1	0.43	0.09	0.41	0.35	0.79	0.13	0.44
tot. Coliform	200	300	120	4					
Fecal Coliform	10	0	0	0					

* strong colour, prevented analysis
*1 insufficient sample
ND not detected

TEST SET GROUP G-B GROUND WATER MONITOR:BH 12-1

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	860623
Conductivity	1100
pH	7.5
Hardness	611
Alkalinity	220
Chloride	285
tot. Kjeldahl	2.3
Calcium	170
Sodium	160
Free Ammonia	0.8
Nitrate	0.15
Nitrite ug/l	0.03
Phenol ug/l	0.09
BOD	0
COD	45.6
Sulphate	320
Phosphate	0.02
Phosphorous	-
PCB ug/l	4.2
Chromium	0.17
Copper	0.01
Iron	0.38
Nickel	0
Zinc	0.04
tot. Coliform	-
Fecal Coliform	-

* strong colour, prevented analysis
*1 insufficient sample
ND not detected

APPENDIX F

COMBUSTIBLE GAS MEASUREMENTS, 1982-1985

PROJECT UPPER OTTAWA STREET LANDFILL % COMBUSTIBLE GAS SHEET 1

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

MONITOR \ Date	Apr 22 1982	Oct 27 1982	Dec 12 1982	Apr 20 1983	June 15 1983	Aug 25 1983	Oct 26 1983	Jan 26 1984	Feb 24 1984	Mar 27 1984	Apr 27 1984
GM 1	0	0	0	0	0	0	0	0	0	0	0
GM 2	-	-	0	0	0	0	0	0	0	0	0
GM 3	-	-	0	0	0	0	0	0	0.5	0	0
GM 4	0	0	0	0	0	0	0	0	0	0	0
GM 5	0	0	0	0	0	0	0	0	0	0	0
GM 6	0	0	0	0	0	0	0	0	0	0	0
GM 7	0	0	0	0	0	0	0	0	0	0	0
GM 8	0	0	0	0	0	0	D	E S	T R	O Y	E D
GM 9	0	0	0	0	0	0	0	0	0	0	0
Quonset Hut	-	-	4	5+	5+	-	0	0	0	0	0

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT UPPER OTTAWA STREET LANDFILL % COMBUSTIBLE GAS

SHEET 2

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

Date / MONITOR	June 27 1984	Aug.17 1984	Oct.18 1984	Apr.23 1985	July 9 1985						
GM 1	0	0	0	0	0						
GM 2	0	0	0	0	0						
GM 3	0	0	0	0	0						
GM 4	0	0	0	0	0						
GM 5	0	0	0	0	0						
GM 6	0	0	0	0	0						
GM 7	0	0	0	0	0						
GM 8	Destroyed →										
GM 9	0	0	0	-	0						
Quonset Hut	0	0	0	-	-						

NOTE : concentrations in p.p.m. unless otherwise noted.

APPENDIX G

TERMS OF REFERENCE

Request for Quotations

Upper Ottawa Street Landfill Site
1985 Monitoring Program
Consulting Services

Terms of Reference

Task A:

To gauge stream flows and collect water samples at stations SW 1, SW 2, SW 4 and SW 7 and gauging station SG 4 of the Redhill Creek, as shown on the attached site plan, during a sustained low flow period in August or September 1985.

The water samples will be tested for chemical analysis at the Regional Laboratory for the following parameters: Conductivity, pH, chloride, total Kjeldahl Nitrogen, Iron, Free Ammonia, Phenol, BOD and PCB.

This activity is to be co-ordinated with the ground water monitoring and the sampling and collection of sediment samples which is the responsibility of the Region.

Task B:

This task will include the analysis and concentration - time plots for the various parameters tested both in the ground and surface waters from monitoring performed in November 1984 and during May and August - September 1985, as well as mass balance calculations from data obtained under task "A".

Monitoring results will be forwarded to your company to allow completion of task "B". This task will also include an assessment on the condition in the physical setting during the field work (task "A") that may be related to the landfill.

A monitoring program report is to be submitted which will contain the results, conclusions and recommendations.

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